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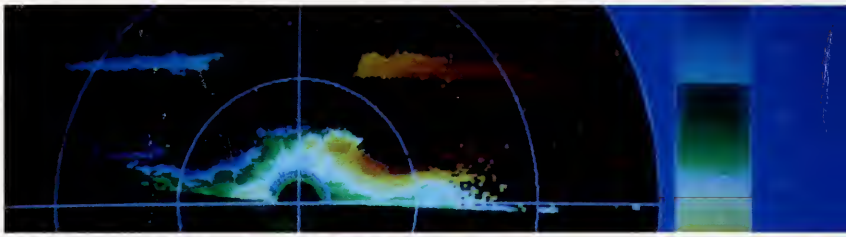

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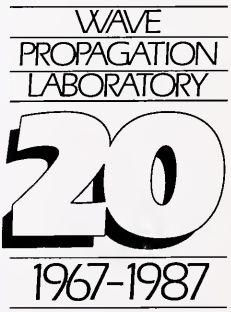
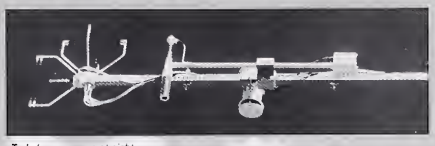
Advances in remote sensing have forever changed the way we observe our environment. Our ability to reach out with acoustic and electromagnetic waves has provided new insights into the behavior of the atmosphere and oceans.

The Wave Propagation Laboratory celebrates its twentieth year of contributions to remote sensing. Through a blend of theory and applications, of science and technology, WPL has been able to perceive needs, conceive remote sensing solutions, and develop them for operational use.

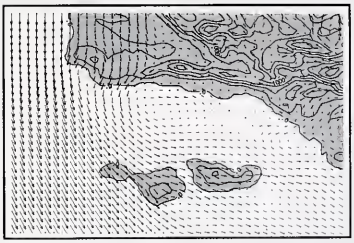


WPL's remote and in-situ sensors are being applied to a broad range of atmospheric studies. Meanwhile, the search for new techniques to probe the atmosphere and oceans continues.

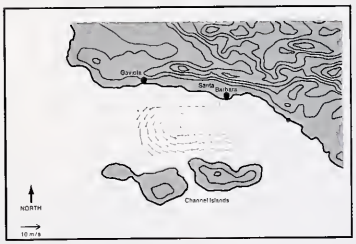


Turbulence sensors at eight levels on the tower.

Our understanding of terrain effects on flows near mountain ranges and ocean channels has been advanced through coordinated computer modeling and remote sensor observations. The computer plots below illustrate the type of mutual verification possible. The distinctive eddy induced in the Santa Barbara channel by terrain features along the coast has implications for oil exploration in the channel.

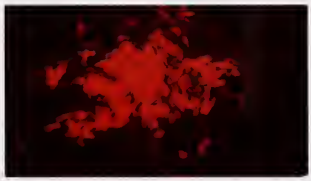


Model prediction.



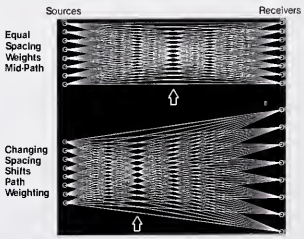
Radar measurement.

Laser crosswind sensors monitor flow across beam paths several kilometers long. When a laser beam propagates through the atmosphere, turbulence breaks up the beam into irregular patches that move with the wind. By correlating the time delay between two adjacent optical receivers, a measure of the crosswind velocity is obtained.



Laser beam after propagation through turbulent air.

Two transmitter-receiver configurations for flow measurement.



Spatial arrays of transmitters and receivers can be devised to pinpoint measurements of transverse flow along the beam paths. Acoustic transmitters and receivers deployed in an array of moorings, transmitting sound in a criss-crossing network of paths, provide three-dimensional information on the temperatures and currents in the open oceans.

The Boulder Atmospheric Observatory

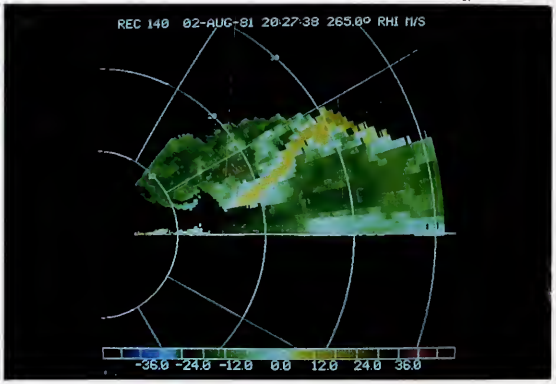
The Boulder Atmospheric Observatory with its 300-m instrumented tower has served the needs of both boundary layer scientists and designers of remote sensors. Sophisticated turbulence sensors on the tower are useful for boundary layer experiments and for calibration of remote and in situ atmospheric sensors.

Acoustic and microwave remote sensors are providing detailed information on the structure of the lower troposphere for studies of events such as drainage winds, gust fronts, and microbursts that affect our environment, the quality of the air we breathe, and our safety.

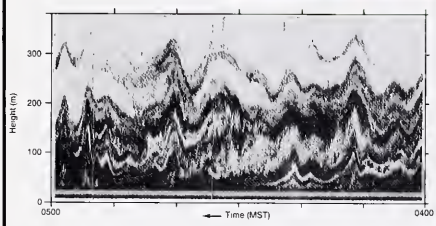
Doppler radar operating at 3-cm wavelength.

Acoustic sounder measuring winds in a canyon.

Doppler radar scan through a gust front.

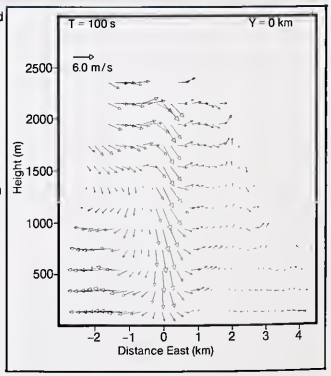


Acoustic sounder display of thermal structure.



Echo returns from acoustic sounders trace a changing pattern of layers of laminar and turbulent air within the lowest 500 meters. With added Doppler wind-sensing capability, they measure velocity profiles of flow in canyons and drainage basins to aid in a wide variety of pollutant transport and diffusion studies.

Color displays of gust fronts and microbursts from our Doppler radars allow us to analyze those hazardous events and to develop predictive tools for airport use. The radar systems operate in pairs, scanning the same spatial volume from different locations to provide information on the three-dimensional structure of the wind field. Strong downward velocities in microbursts, and the divergence created at the surface, are clearly apparent in wind field plots generated from dual-Doppler measurements made with our 3-cm radars.

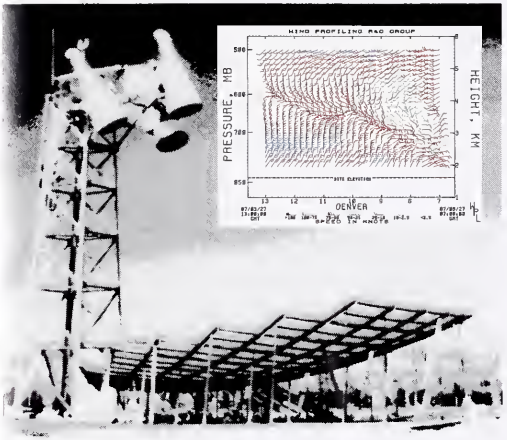


Vertical cross section of wind field in a microburst, plotted from dual-Doppler measurements.

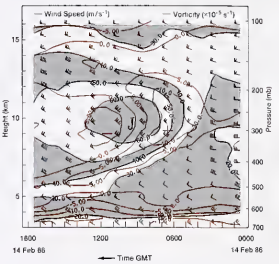
Multibeam Doppler radars operating at wavelengths from 0.3 to 6 meters measure vertical profiles of horizontal winds throughout the troposphere. These "Wind Profilers" operate in the optically clear atmosphere to provide time-height cross sections of the horizontal wind field with temporal resolution ranging from 10 minutes to 1 hour.

Wind Profiler at Stapleton Airport, operating at 0.33-m wavelength.

Gust front passage as recorded by the wind Profiler at Stapleton Airport.

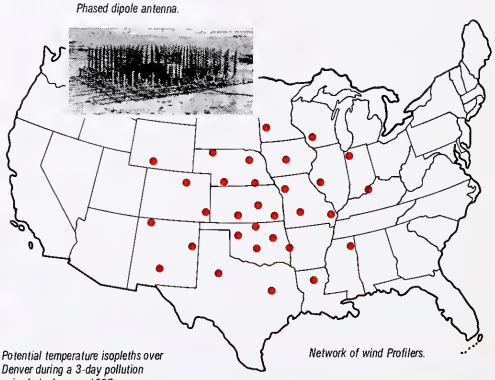


Isopleths of mean winds and vorticities, showing passage of an upper-level jet, computed from a three-station network of 6-m wind Profilers in eastern Colorado.



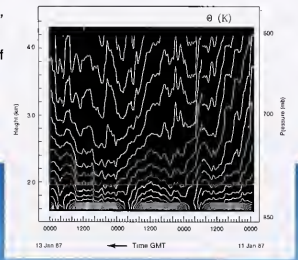
A new generation of wind Profilers has been developed for deployment in a network covering the central United States. The Profilers operate at 0.75-m wavelength and use phased dipole arrays as antennas. Hourly-averaged winds will be collected and disseminated to the National Weather Service and other users.

Phased dipole antenna.

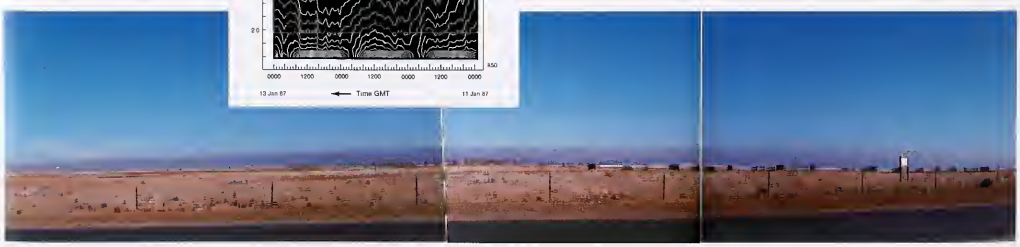


Network of wind Profilers.

Operating in conjunction with the wind Profilers, passive radiometers measuring "brightness" within selected oxygen and water vapor bands yield vertical profiles of temperature and humidity. Close spacing of potential temperature isopleths signifies strong stabilities responsible for pollution episodes, which sometimes last several days.



Potential temperature isopleths over Denver during a 3-day pollution episode in January 1987.



Denver skyline viewed from Boulder on the evening of the second day of the 3-day pollution episode.

Newer and more powerful lidars are being deployed in field experiments to study flows within gust fronts and microbursts, over ridges and within canyons.

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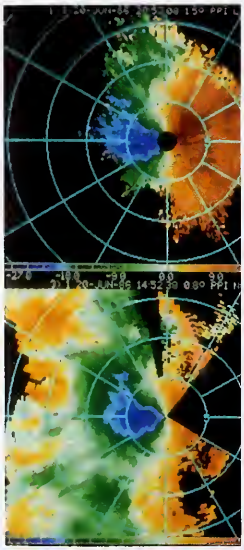
A gust front as observed by Doppler lidar (above) and Doppler radar (below).



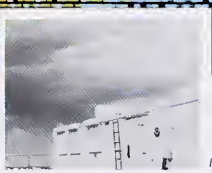
Multiwavelength lidar.

Multiwavelength lidars capable of measuring oil fog concentrations in the atmosphere have been used in controlled experiments to study plume dispersion over mountain ridges and other terrain features. Cross sections of concentrations at different points downwind of the source are obtained from vertical scans with the lidar.

Oil fog illuminated by a vertically scanning lidar in a study of flow over a uniform ridge.

Our pulse Doppler lidar can map wind fields within long narrow canyons and city streets. The extremely narrow beam of the lidar permits wind measurement within a meter of obstacles and side walls.

Vertical cross section of horizontal winds within a canyon, as measured by Doppler lidar.



Infrared pulse Doppler lidar.

For further information:

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U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Environmental Research Laboratories

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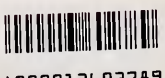
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